THE EFFECTS OF UCS DURATION AND UCS INTENSITY ON THE MAGNITUDE OF CONDITIONED FEAR

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THESIS APPROVAL SHEET

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INTRODUCTION

Fear has generally been considered to be an internal response which may be brought under stimulus control via the associative process of Pavlovian conditioning. That is to say, when a neutral stimulus is repeatedly presented either prior to or simultaneously with a painful unconditioned stimulus (UCS), it becomes a conditioned stimulus (CS) and, when presented alone, is capable of eliciting the fear response. Since conditioned fear is assumed to be an internal response, it is usually measured indirectly through observable responses. Typically, the fear-eliciting CS is presented and the subsequent change in some observable response is measured. It is assumed that the response change is a consequence of the fear elicited by the CS and, furthermore, that a correlation exists between the degree of the response change and the magnitude of the fear response.[1] The response measures traditionally used to index fear may be assigned to one of the following two categories: (a) changes in physiological responses (e.g., heart rate, skin resis-

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[1]The magnitude of the fear response is used quite loosely in this paper. No distinction is made as to whether the magnitude of the response refers to its momentary intensity (amplitude) or to its duration. It is merely assumed that the greater the magnitude of fear the greater will be its effect on the indicant response.

tance) and (b) changes in instrumental responses (e.g., bar-pressing, alley-running, hurdle-jumping).[2]

Although the amount of conditioned fear has been shown to be related to various parameters of the Pavlovian conditioning paradigm, the role of UCS duration is still uncertain. It seems reasonable that the amount of fear elicited by a CS should be directly related to the duration of the UCS that was employed during conditioning. That is, one would probably expect a CS which signals the subsequent occurrence of a long painful stimulus to be more fear-evoking than one which signals the forthcoming of a brief painful stimulus. Surprisingly, this intuitive notion has not received consistent support when empirically tested.

Studies which have employed changes in physiological responses as indices of fear have consistently indicated that the magnitude of conditioned fear is unrelated to UCS duration. Bitterman, Reed, and Krauskopf (1952) found no differences in the magnitudes of galvanic skin responses (GSRs) of male undergraduate students when the effects of 0.5-sec. and 3.0-sec. UCS durations were compared; Wegner and Zeaman (1958) found no differences in heart rate disturbances of male and female undergraduate students when the effects of

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[2]McAllister and McAllister (in press) present a comprehensive review and evaluation of the behavioral measurement of fear.

0.1, 2.0, 6.0, and 15.0-sec. UCS durations were compared; Sawrey and Sawrey (1968) found no differences in rates of stomach ulceration of male rats when the effects of .25-sec. and .75-sec. UCS durations were compared.

In contrast, the findings of studies which have employed changes in instrumental responses as indices of fear have indicated that UCS duration is an effective variable. In a between subjects (Ss) design, Mowrer and Solomon (1954) trained four groups of male rats to bar-press for food and, in a different stimulus situation, administered fear conditioning. The four groups differed as to the duration of the UCS and as to the nature of UCS termination. The CS, a 3.0-sec. blinking light, was paired with either a 3.0-sec. UCS which terminated abruptly (Group I), a 4.0-sec. UCS which terminated gradually (Group II), a 7.0-sec. UCS which terminated gradually (Group III), or a 10.0-sec. UCS which terminated abruptly (Group IV). The amount of fear conditioned to the CS was assessed during a 30.0-min. test session. For the first 5.0 min., S was allowed to bar-press for food pellets, but for the remaining 25.0 min., the presentation of the CS (which had presumably acquired fear-evoking properties from its pairings with the UCS) was presented immediately after each bar-press response. This procedure is analogous to primary punishment when the presentation of an unconditioned aversive stimulus is made contingent upon the S emitting a particular

response. Since a conditioned aversive stimulus (i.e., the CS) was substituted in the place of the unconditioned aversive stimulus, the Mowrer and Solomon procedure may be properly called conditioned punishment. The extent to which bar-pressing was inhibited was thought to be directly related to the magnitude of fear elicited by the CS. Although the results of the study showed no statistically reliable differences between the four groups, Mowrer and Solomon found that Group I, which received the 3.0-sec. UCS, tended to be less fearful than the other three groups (the difference was at the 10% level of confidence). On the basis of this finding, Mowrer and Solomon conjectured that

> we have here the beginning of a tendency which could almost certainly be demonstrated if the shock were made very brief, say 0.5-sec. duration; it is virtually certain that it would be reliably less effective in producing fear than would a shock of longer duration (p.21).

The prediction of Mowrer and Solomon was empirically tested in two studies by Overmier (1966a, 1966b) when he compared the effect of a 0.5-sec. UCS to that of a 50.0-sec. UCS. The Ss, adult mongrel dogs, were trained in a shuttle-box to jump a hurdle within 10.0 sec. after the onset of a visual stimulus in order to avoid a subsequent electric shock. In a different stimulus situation, the same Ss were given fear-conditioning trials. A tone was paired with a 50.0-sec. UCS, and another tone, which differed in frequency from the first, was paired with a 0.5-sec. UCS. The amounts

of fear conditioned to the two tones were assessed when the two tones and the visual stimulus were separately presented to S in the shuttlebox. During this session, shock was never presented. It was presumed that the hurdle-jump response would be mediated through the fear produced by each of the two tones.[3] It was also assumed that the amount of fear associated with each stimulus would be indexed by the speed of the hurdle-jump response. That is, the assumption was made that the magnitude of conditioned fear was positively related to hurdle-jump speed. When tested for transfer of avoidance training, Ss in both of the studies responded faster when presented with the tone previously paired with the 50.0-sec. UCS than they did to the tone previously paired with the 0.5-sec. UCS. As expected, Ss responded most quickly to the visual stimulus, since that stimulus had already been conditioned to occasion the instrumental hurdle-jump response. The major difference between Overmier's two studies is that the latter study also recorded heart rates during fear conditioning. Although the cardiac indices showed that the learning of fear had occurred, they were not able to predict the differences in performance between the two experimental groups during transfer of avoidance train-

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[3]The reader is referred to Solomon and Turner (1962) for a discussion of the theoretical interpretation of the transfer of avoidance training procedure.

ing. This finding prompted Overmier to suggest that ANS responses, when used as indices of fear, may not be as sensitive as skeletal-motor response indices.

Strouthes (1965) presented findings that at relatively short UCS durations the strength of conditioned fear is not directly related to UCS duration, but is inversely related to UCS duration. Male albino rats were trained to run down a straight runway to obtain food reward. In a different apparatus, the same Ss were administered fear-conditioning trials. The experimental groups received UCS (electric shock) durations of either .25, .85, or 1.90 sec. The CS was a 0.3-sec. blinking light which, when terminated, was followed immediately by the UCS. The effect of the CS was determined during a test period when Ss were again permitted to run down the runway to obtain food. However, this situation differed from the previous situation in that the blinking light (mounted above and in front of the food cup) was presented when the start box door was raised and was not terminated until S reached the goal box. Therefore, as S approached the goal box, it placed itself in closer proximity to the blinking light (which presumably elicited fear). Strouthes assumed that the running speeds during the test period were inversely related to the amount of fear elicited by the blinking light. Each S was given a total of 25 test trials over three test periods on three consecutive days.

Only the first test trial indicated significant differences in performance between experimental groups. The running speeds of Ss who received the CS paired with the .25-sec. UCS did not differ significantly from the running speeds of Ss who received the CS paired with the .85-sec. UCS, but the running speeds of both of these groups were significantly slower than the running speeds of Ss who received a 1.90-sec. UCS following the CS.

To say the least, the results of studies which have manipulated UCS duration as a parameter have been inconsistent. The magnitude of conditioned fear has been shown to be (a) independent of UCS duration when changes in physiological responses were used as indices of fear (Bitterman, et al., 1952; Wegner and Zeaman, 1958; Sawrey and Sawrey, 1968) and (b) both positively related to UCS duration (Mowrer and Solomon, 1954; Overmier, 1966a, 1966b) and inversely related to UCS duration (Strouthes, 1965) when changes in instrumental responses were used as indices of fear. (The above findings are summarized in Table 11 in Appendix A) The nature of the function relating UCS duration to the strength of conditioned fear still remains to be discovered.

The present experiment was an attempt to ascertain further the role of UCS duration. Specifically, the effects of three durations, 0.5, 3.0, and 10.0 sec., were compared. Because Mowrer and Solomon (1954) found the difference be-

tween the amounts of fear produced by a 3.0-sec. UCS and a 10.0-sec. UCS to approach significance ($p < .10$), it was felt that these two durations deserved further comparison. The 0.5-sec. duration was shown by Overmier (1966a, 1966b) to be relatively poor in producing fear; furthermore, this same value was the duration suggested by Mowrer and Solomon that "would be reliably less effective in producing fear than would a shock of longer duration (p.21)." The comparison between the durations of 0.5 sec. and 3.0 sec. seems even more appropriate when the findings of Strouthes (1965) are taken into account. His results suggest that a 1.90-sec. UCS produced less fear than either a .25-sec. or a .85-sec. UCS. If, indeed, there is an inverse relationship between the strength of conditioned fear and UCS duration at low levels of UCS duration, then the results of the present study should show more conditioned fear resulting from the 0.5-sec. UCS than from the 3.0-sec. UCS.

If UCS duration was varied only a single level of UCS intensity, anything that could have been inferred from the results of the present study would have necessarily been restricted to that specific level of UCS intensity. Therefore, each UCS duration was investigated at <u>three</u> levels of UCS intensity, namely, 0.5, 1.0, and 3.0 ma. This factorial design allowed the present experimenter (<u>E</u>) to determine whether UCS duration and UCS intensity interact, at least

over the values employed in this study, to determine the magnitude of conditioned fear. As to the effect of UCS intensity, prior research has consistently shown the strength of fear to be an increasing monotonic function of this variable (e.g., Annau and Kamin, 1961; McAllister and McAllister, 1962; Strouthes and Hamilton, 1964).

A conditioned punishment procedure similar to the one used by Mowrer and Solomon (1954) was employed. The experimental groups were trained to bar-press for food reward in an operant chamber and, later, conditioned to fear a discrete CS in a different stimulus situation. The magnitude of the fear conditioned to the CS was assessed during five subsequent conditioned punishment sessions in the operant chamber. During these sessions, each bar-press response emitted by S was immediately followed by the presentation of the CS. A theoretical interpretation of this conditioned punishment procedure will now be presented. It is assumed that the presentation of the CS results in the elicitation of fear reactions such as crouching, freezing, and defecating, and these fear reactions, in turn, are assumed to compete with the tendency to approach the bar and press it for food. Furthermore, since the bar-press response precedes the presentation of the CS, stimuli which accompany that response (these stimuli may be visual, tactual, kinesthetic, etc.) are in close temporal contiguity with the CS; thus,

through higher-order conditioning, they become conditioned to elicit fear reactions. When a subsequent approach response toward the bar is made, some of these stimuli will again be present; consequently, the fear reactions elicited by these stimuli will compete with the tendency to bar-press. Clearly, what determines whether or not S will continue bar-pressing are the relative strengths of (a) the tendency to approach the bar and (b) the fear reactions. Since the CS is always presented without the UCS during conditioned punishment, it may be expected that the fear reactions will gradually extinguish. As the extinction of fear progresses, the fear reactions will compete less and less successfully with the bar-press response, and the rate of bar-pressing will eventually return to normal. It is assumed that the amount of time elapsing before bar-pressing returns to its normal rate is a positive function of the magnitude of fear conditioned to the CS. In the present study, the tendency to bar-press was presumably the same for all groups, since all Ss received the same amount of prior bar-press training as well as the same amount of food deprivation. Therefore, any between-group differences in bar-press performance during the conditioned punishment session may be assumed to have been a result of different amounts of fear being conditioned to the CS during Pavlovian fear conditioning.

There were two major procedural differences between the present study and the Mowrer and Solomon (1954) study. First, each S in the present study was given 25 CS-UCS pairings during fear conditioning as compared to 5 CS-UCS pairings given by Mowrer and Solomon. It was thought by the present E that 5 CS-UCS pairings may have been too few and that increasing the number of pairings might magnify the difference between the effects of the 3.0-sec. and 10.0-sec. UCSs. Stated differently, it was believed that the number of CS-UCS pairings and the duration of the UCS may interact, with the difference between the effects of the 3.0-sec. and the 10.0-sec. UCSs beings small when the number of CS-UCS pairings is 5, but the difference being larger when the number of CS-UCS pairings is 25. The second difference concerned the amount of bar-press training given. Each S in the Mowrer and Solomon experiment bar-pressed approximately 70 times on a continuous reinforcement (CRF) schedule before it received its first conditioned punishment, while each S in the present study bar-pressed an average of 1200 times. Because the strength of conditioned fear in the present study was assessed by comparing the rate of S's bar-pressing during conditioned punishment to its normal rate of bar-pressing prior to conditioned punishment, it was necessary to allow the rate of bar-pressing to reach an asymptotic level prior to conditioned punishment before a normal rate

of responding could be determined.[4]

For the purpose of obtaining additional information, a tenth group was incorporated into the experiment as a pseudoconditioning control group for one of the experimental groups.[5] This group was incorporated into the design to assess the amount of bar-press inhibition that could not be attributed to the forward conditioning procedure. What was needed was a group which received the same number of CS and UCS presentations but in an order that would not result in fear being conditioned to the CS. The traditional control procedure is to administer backward conditioning trials (i.e., the CS is always preceded by the UCS) during fear conditioning. According to Rescorla (1967), this procedure is inadequate. He proposed that whether a CS will come to elicit fear depends upon how well it predicts the subsequent occurrence of the UCS. A CS that has always been followed by a UCS will elicit fear. On the other hand, a CS which had never been followed by a UCS will have come to predict the nonoccurrence of the UCS and, thus, will inhibit fear. Rescorla argued that the only adequate control for Pavlovian

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[4]Pilot work in this laboratory has shown that several hundred bar-press responses on a CRF schedule are required for S to reach a stable rate of performance.

[5]Pseudoconditioning is defined in Kimble (1961, p. 482) as: "The strengthening of a response to a previously neutral stimulus through the repeated elicitation of the response by another stimulus without paired presentation of the two stimuli."

fear conditioning is to present the CS and the UCS in a completely random order so that the CS neither predicts the occurrence or nonoccurrence of the UCS. In the present study, this completely random control procedure was employed. The control group received the same number of CS and UCS presentations as its respective experimental group during fear conditioning, but the order of presentation of the CSs and the UCSs for the former group was randomly determined.

Chapter 2

METHOD

Subjects

The 70 naive male albino rats which were used as Ss were approximately 90 days of age at the start of the experiment. All Ss were purchased from the Sprague-Dawley Company in Madison, Wisconsin.

Apparatus

A Gerbrands Model C operant conditioning chamber was used to train Ss to bar-press for food reward. By pressing a button which operated a magazine, E was able to release a 45-mg. Noyes food pellet into a food cup. A white cardboard floor was placed into the chamber to cover the grid floor of the unit.

An identical operant chamber was converted into a fear-conditioning compartment by constructing three partitions and a ceiling within the chamber. The compartment was 18.10 cm. long, 15.24 cm. wide, and 9.21 cm. high. The ceiling and three of the walls were black, while the fourth wall consisted of the plexiglass wall of the original chamber. The operant conditioning chamber and the fear-conditioning compartment were made to appear as different as possible to prevent fear from being elicited by

the apparatus cues of the operant chamber through the process of stimulus generalization.

The CS used in fear conditioning was a 2.0-sec. 400 cycles per second tone produced by a noise generator, and it was presented to S through a 3.0-in. speaker which was mounted at the rear of the compartment below the level of the grids.

The UCS was administered to S through the grid floor or the fear-conditioning compartment by a Grason Stadler Model E1064GS Shock Generator. The intensity of the UCS was controlled by the settings on the shock generator. The durations of the CS and the UCS were controlled by Hunter Model 111-C Decade Interval Timers.

Procedure

After their arrival from the laboratory animal distributor, Ss were housed in individual cages and maintained on an *ad libitum* feeding schedule of Purina laboratory chow for a minimum of seven days before the start of the experiment. During the course of the experiment, Ss were allowed free access to water in their home cages. Constant artificial light illuminated the colony room in which the home cages were kept. Three days before the start of the experiment Ss were placed on a feeding schedule which allowed them to eat Purina laboratory chow for only 1 hr.

each day; S was handled by E for approximately 10 min. during each of those 3 days. The Ss were randomly assigned to ten groups, with each group consisting of seven Ss.

Bar-press training. On Days 1-7 of the experiment, Ss were trained to press a bar in the operant chamber to obtain a pellet of food. The general procedure during these days was to (a) give S a 15.0-min. bar-press training session, (b) return S to its home cage for a 1.0-hr. period, and (c) allow S to feed for a 1.0-hr. period. On Day 1, S was trained to respond to the click of the magazine by approaching the food cup and eating the pellet of food. The S received bar-press shaping sessions on Days 2 and 3 during which E, at first, rewarded responses approximating the bar-press response but later rewarded only the bar-press response itself. Since all Ss learned to bar-press by the end of the third day (Day 3), E was able to set the controls on the apparatus so that S would automatically receive a food pellet after making a bar-press response. The S was then given four more daily 15.0-min. sessions (Days 4-7) to bring its rate of bar-pressing up to a stable level. The S remained on a CRF schedule throughout the remainder of the experiment.

Fear conditioning. After the bar-press session on Day 7, S was returned to its home cage for 30 min. The S was then taken from its home cage and placed into the fear-con-

ditioning compartment where it received a 15.0-min. fear-conditioning session. The S was then returned to its home cage and after a 30.0-min. period was allowed to eat for 1.0 hr. This same procedure was continued on Days 8-11.

The Ss in the experimental groups received the 2.0-sec. CS with the UCS immediately following the termination of the CS. Five CS-UCS pairings were given during each 15.0-min. session. The inter-presentation interval (IPI), i.e., the interval between CS-UCS pairings, averaged 150.0 sec., with values of 110, 130, 150, 170, and 190 sec. being employed. The time elapsing from the placement of S into the fear-conditioning compartment to the presentation of the first CS-UCS pairing was considered to be the first IPI. The order of IPIs were randomly chosen for each of the five fear-conditioning sessions. The randomly selected order of CS and UCS presentations and their temporal relationships during each of the five fear-conditioning sessions for the control group is shown in Table 12 in Appendix B.

Conditioned punishment. On Days 12-16, Ss were placed in the operant chamber for their usual bar-press session. During a session, each bar-press response resulted in the immediate presentation of the CS which had been paired with the UCS during fear conditioning. Positive reinforcement of each bar-press response was continued. After each ses-

sion, S was returned to its home cage for 1.0 hr. and then allowed to eat for 1.0 hr.

To reiterate, the design of the present experiment was a factorial design with UCS duration (0.5, 3.0, and 10.0 sec.) and UCS intensity (0.5, 1.0, and 3.0 ma.) serving as the Between Ss factors and Days (12-16) as the Within Ss factor. The design also included an appended pseudoconditioning control group. Thus, there was a total of 10 groups with each group consisting of seven Ss.

Chapter 3

RESULTS

Acquisition of the Bar-press Response

There were no data collected for Day 1 (magazine training) nor for Days 2 and 3 (bar-press shaping) that could be analyzed. The bar-press performances for each of the experimental groups are presented in Figure 1. The graph indicates that there were no systematic differences in performance between the groups. The performances of the nine groups were combined to form the single performance curve which is presented in Figure 2. Bar-press performance is clearly shown to have improved over the four days.

Fear-conditioning and Bar-pressing

Fear conditioning sessions were given after each bar-press session on Days 7-11. To determine whether bar-press performances were systematically affected by the fear-conditioning sessions, a repeated measures analysis of variance (Lindquist, 1953, Type III) was performed on the data, with UCS Duration and UCS Intensity serving as the Between Ss factors and Days as the Within Ss factor. The analysis is summarized in Table 1, and the data underlying the analysis are depicted in Figures 3 and 4. None of the sources of variation were significant. Therefore, it may be assumed that the fear-conditioning sessions did not systema-

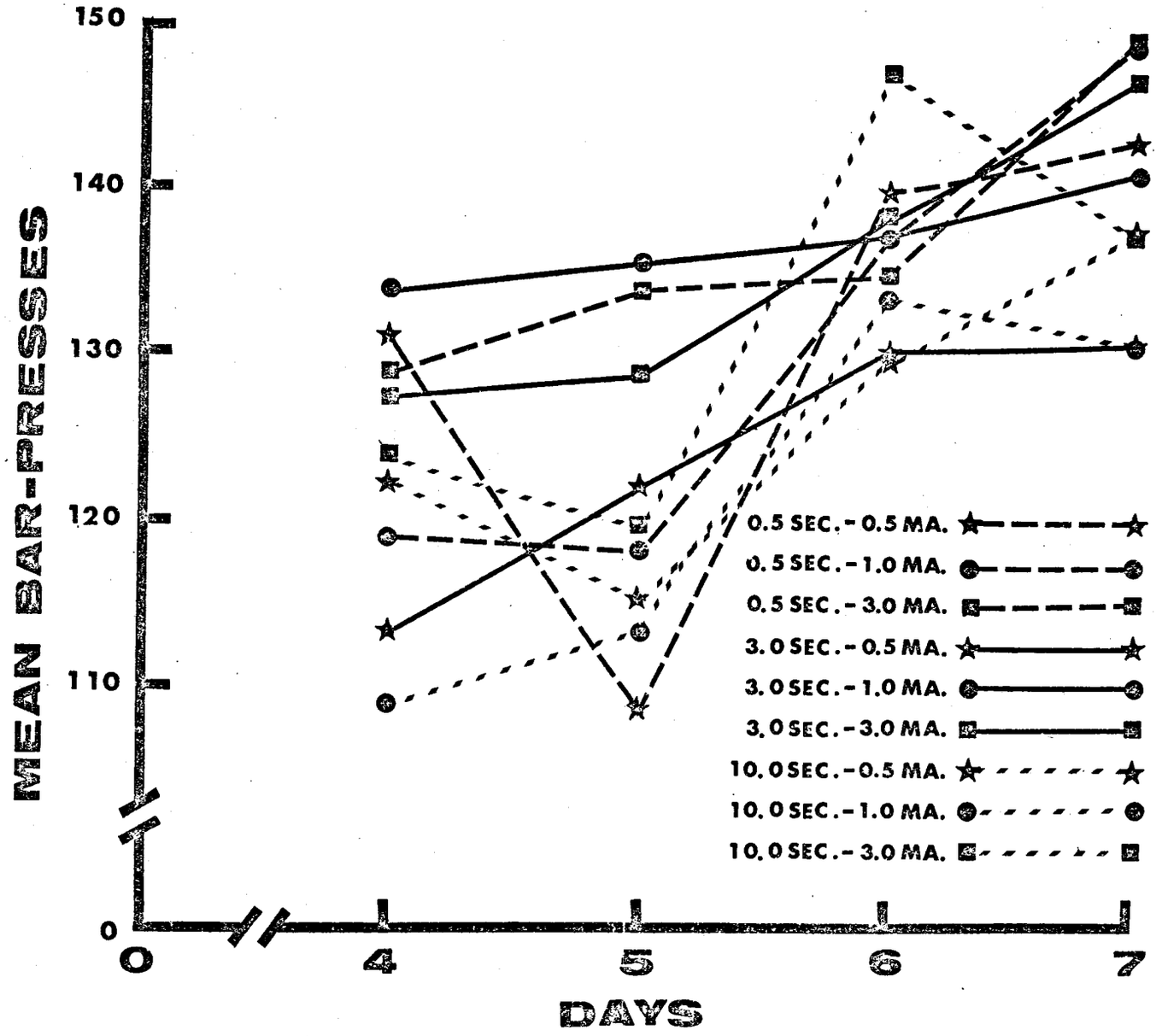

Fig. 1. Mean Bar-presses of the Nine Experimental Groups as a Function of Days 4-7

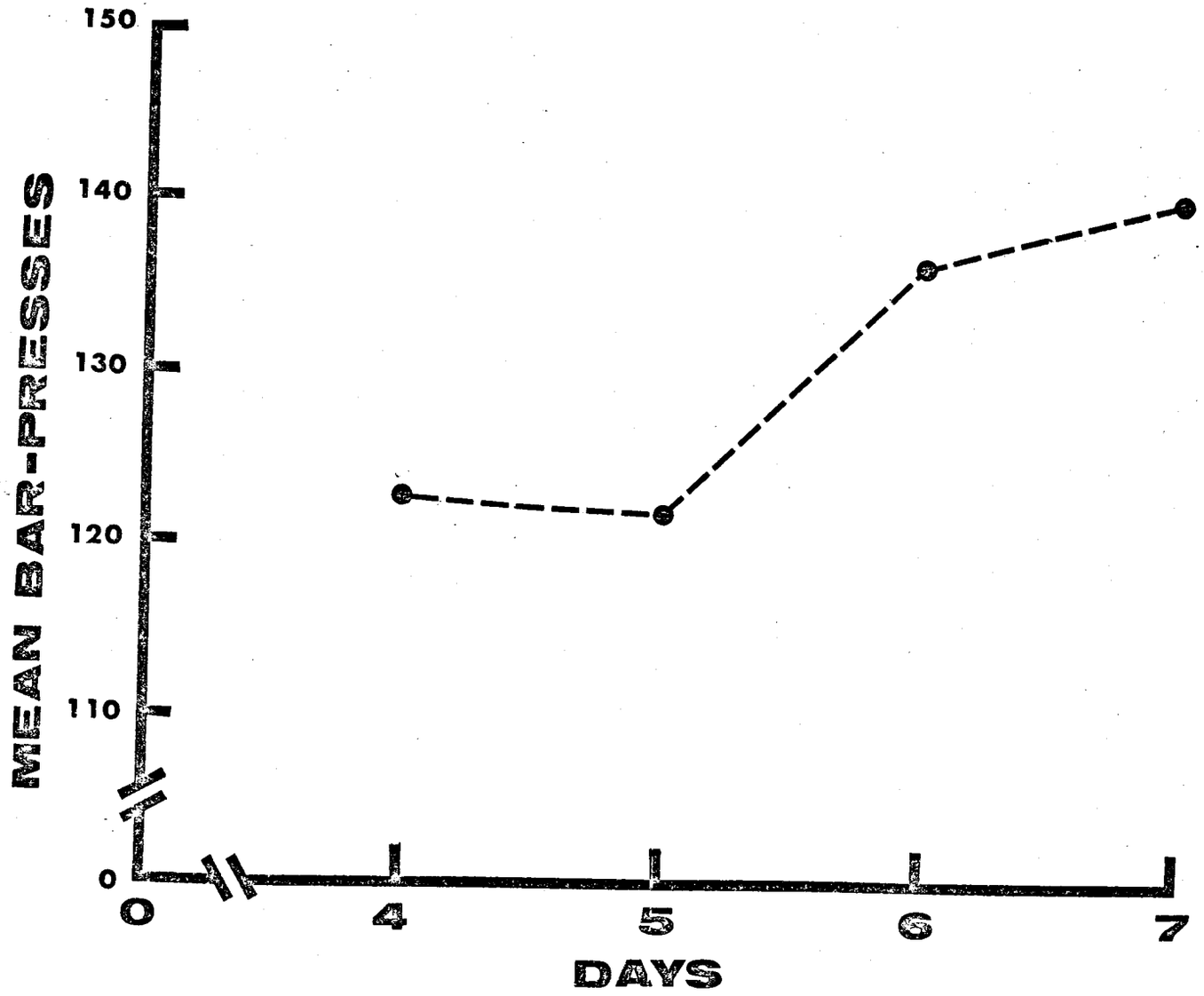

Fig. 2. Mean Bar-presses as a Function of Days 4-7 (collapsed across UCS Duration and UCS Intensity)

Table 1

Summary of Analysis of Variance and Grand Means of Rates of Bar-pressing for the Nine Experimental Groups on Days 8-11 and Hartley Tests

Source	df	Mean	MS	F	p
Between Ss	(62)				
UCS Duration (DUR)	2		328.74	.12	
0.5 sec.		151.20			
3.0 sec.		154.26			
10.0 sec.		150.56			
UCS Intensity (INT)	2		1301.73	.47	
0.5 ma.		148.88			
1.0 ma.		156.43			
3.0 ma.		150.71			
DUR X INT	4		421.35	.15	
Error (b)	54		2745.27		
Within Ss	(189)				
Days (DA)	3		297.15	2.46	
DA 8		150.06			
DA 9		150.83			
DA 10		152.14			
DA 11		155.00			
DA X DUR	6		143.60	1.19	
DA X INT	6		204.34	1.70	
DA X DUR X INT	12		208.25	1.73	
Error (w)	162		120.52		
Total	251				

Hartley Tests	k/n	Fmax.	p
Error b:	9/6	4.70	>.05
Error w:	9/18	3.61	>.05

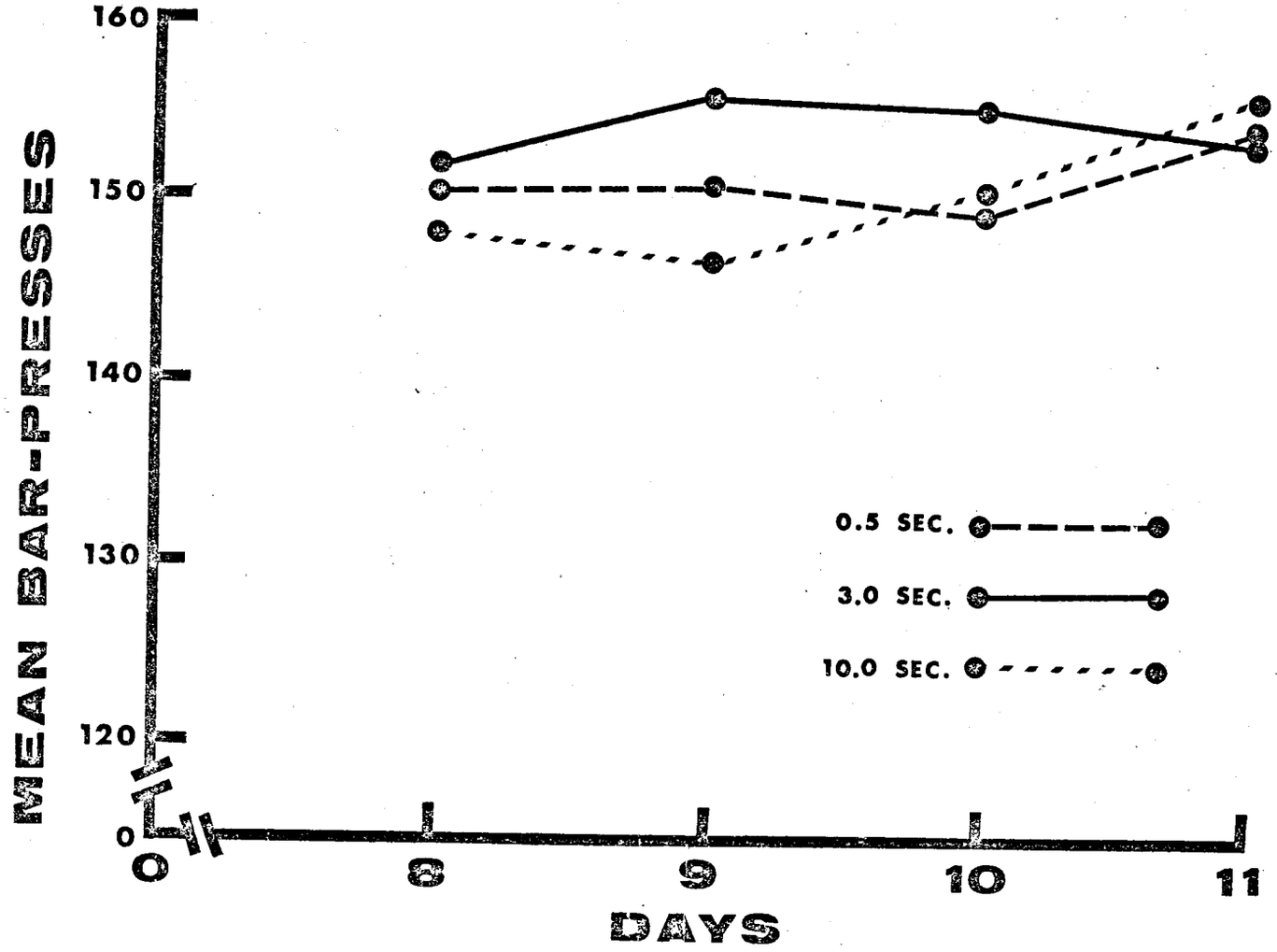

Fig. 3. Mean Bar-presses as a Function of UCS Duration and Days 8-11 (collapsed across UCS Intensity)

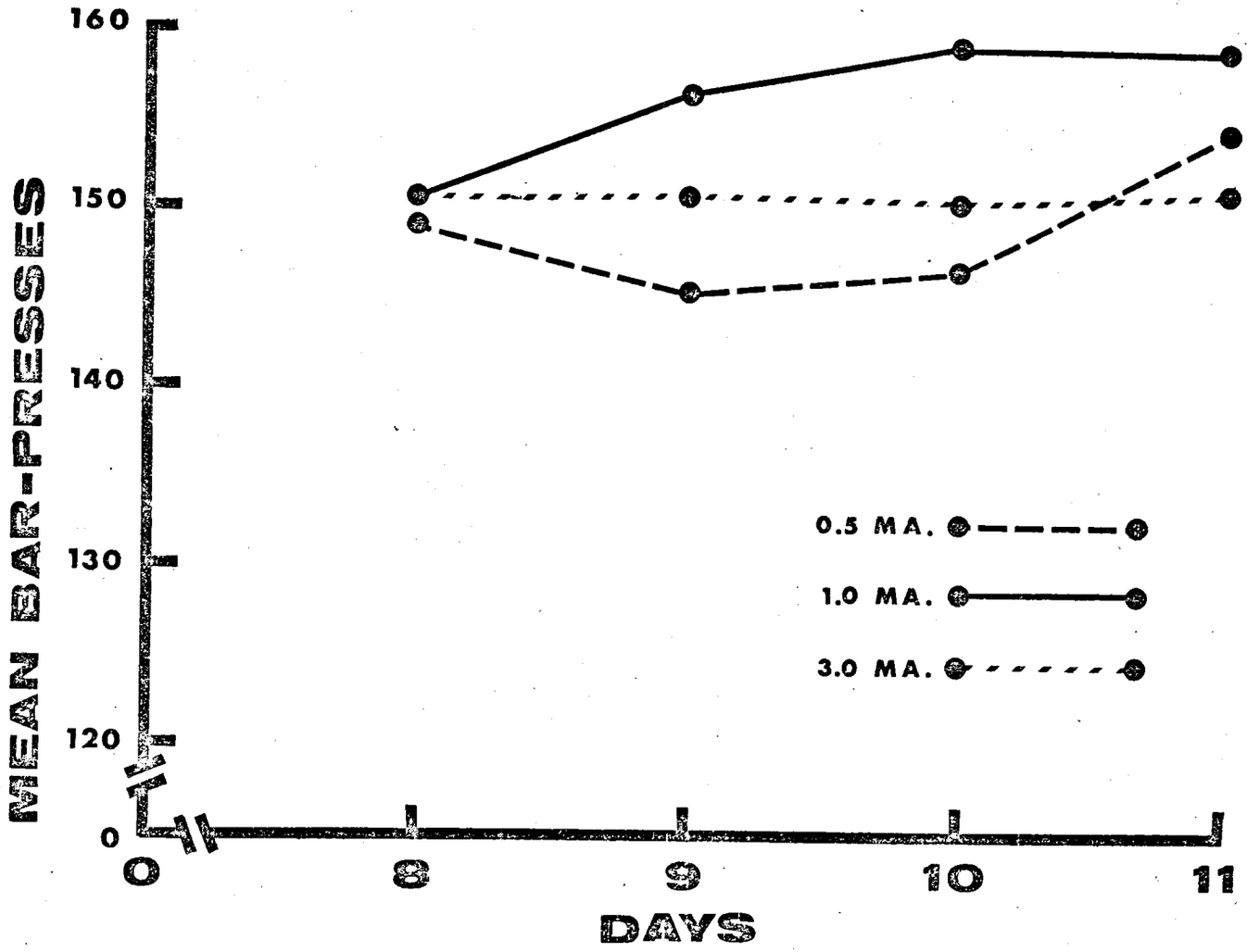

Fig. 4. Mean Bar-presses as a Function of UCS Intensity and Days 8-11 (collapsed across UCS Duration)

tically affect bar-press performances.

Conditioned Punishment

The amount of fear elicited by the CS during conditioned punishment (Days 12-16) was assessed by the use of a bar-press inhibition ratio, B/A, with A representing the normal rate of bar-pressing during a 15.0-min. period before conditioned punishment and B the rate of bar-pressing during any particular conditioned punishment session. The value of A for an S was found by recording the number of bar-press responses emitted during each 15.0-min. bar-press session on Days 9-11 and taking the median of the three scores. The value of B for an S was the number of bar-press responses emitted by that S during the particular 15.0-min. conditioned punishment session. If the presentation of the CS resulted in complete cessation of bar-pressing, the inhibition ratio would be equal to .00. On the other hand, if the CS had little or no effect on bar-press rate, the inhibition ratio would approach or equal 1.00. An inhibition ratio greater than 1.00 indicates that more bar-press responses were made during the conditioned punishment session than during the session from which B was computed. Since there were five conditioned punishment sessions, five inhibition ratios were calculated for each S.

The data for the five days of conditioned punishment

were also analyzed by a repeated measures analysis of variance with UCS Duration and UCS Intensity as the two Between Ss factors and Days (12-16) as the Within Ss factor. Before the data were analyzed, each inhibition ratio was multiplied by a value of 10.0 to facilitate computation. Therefore, an inhibition ratio of .50 would have appeared in the analysis as 5.00; this manipulation in no way affected the outcome of the analysis. A summary of the analysis is presented in Table 2. All inhibition ratios presented in the figures appear in their normal form.

UCS Duration was shown to determine, in part, the amount of fear conditioned to the CS ($F=3.27$, $df=2/54$, $p < .05$). The grand means for each of the three levels of UCS Duration are plotted in Figure 5. The 3.0-sec. duration appears to have been the most effective, while the 0.5-sec. duration appears to have been the least effective. It can be seen in Figure 6 that the same order of effectiveness appeared at each level of UCS Intensity. Individual comparisons were made between the possible pairs of grand means using the Newman-Keuls procedure (Winer, 1962), and the results of these comparisons are presented in Table 3. The mean of the 0.5-sec. level differed significantly from the means of both the 3.0-sec. and 10.0-sec. levels ($p < .05$), but the difference between the means of the 3.0-sec. and 10.0-sec. levels was not significant. (The main

Table 2

Summary of Analysis of Variance and Grand Means of Bar-press Inhibition Ratios for the Nine Experimental Groups on Days 12-16 and Hartley Tests

Source	df	Mean	MS	F	p
Between Ss	(62)				
UCS Duration (DUR)	2		89.60	3.27	< .05
0.5 sec.		7.73			
3.0 sec.		5.90			
10.0 sec.		6.59			
UCS Intensity (INT)	2		452.74	16.54	< .001
0.5 ma.		9.03			
1.0 ma.		6.20			
3.0 ma.		4.98			
DUR X INT	4		16.21	.59	
Error (b)	54		27.37		
Within Ss	(252)				
Days (DA)	4		559.81	124.13	< .001
DA 12		2.24			
DA 13		5.45			
DA 14		7.52			
DA 15		8.76			
DA 16		9.73			
DA X DUR	8		3.28	.73	
DA X INT	8		26.21	5.81	< .001
DA X DUR X INT	16		3.04	.67	
Error (w)	216		4.51		
Total	314				

Hartley Tests	k/n	Fmax.	p
Error b:	9/6	4.70	> .05
Error w:	9/18	3.61	> .05

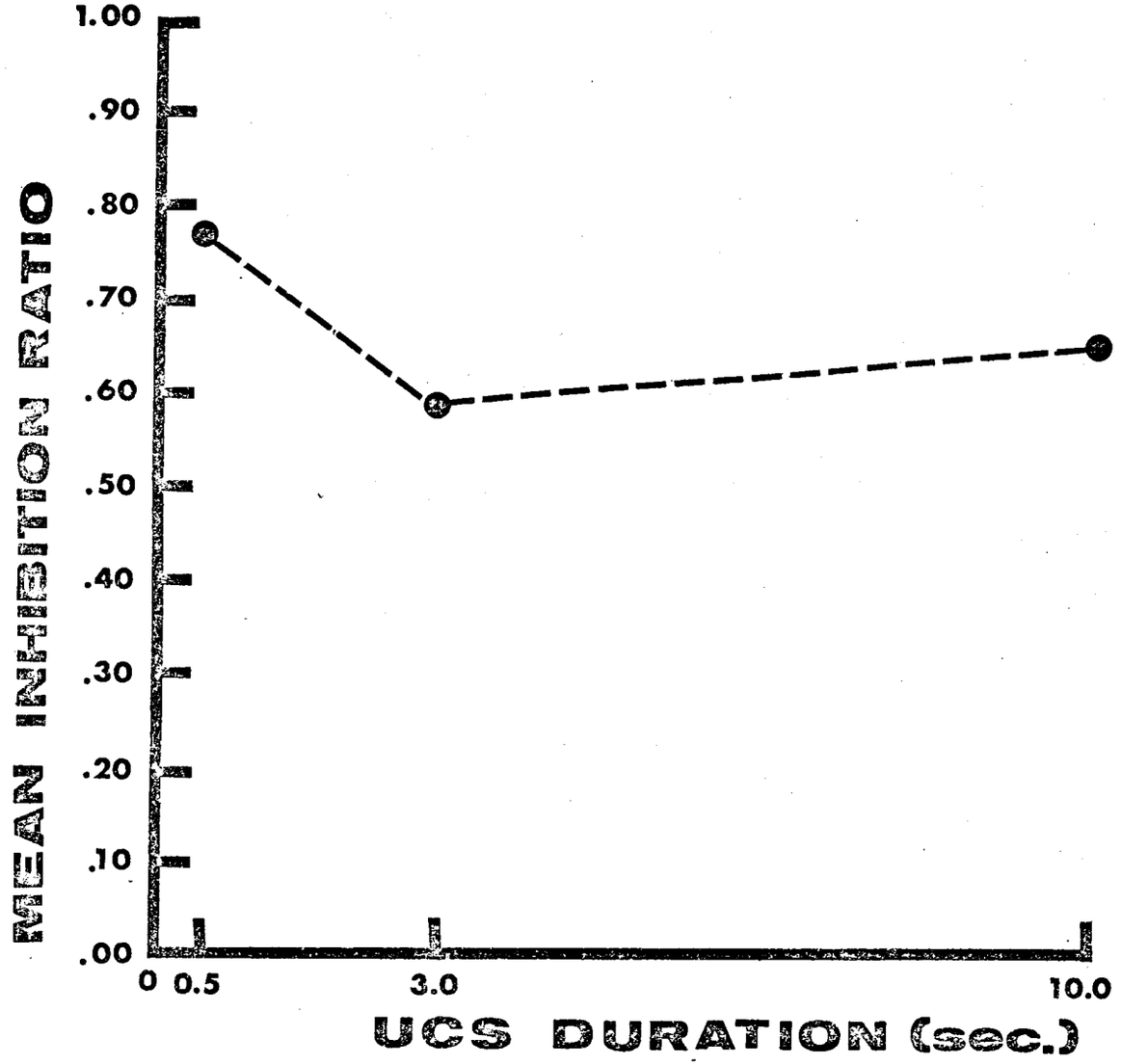

Fig. 5. Mean Inhibition Ratio as a Function or UCS Duration (collapsed across UCS Intensity and Days 12-16)

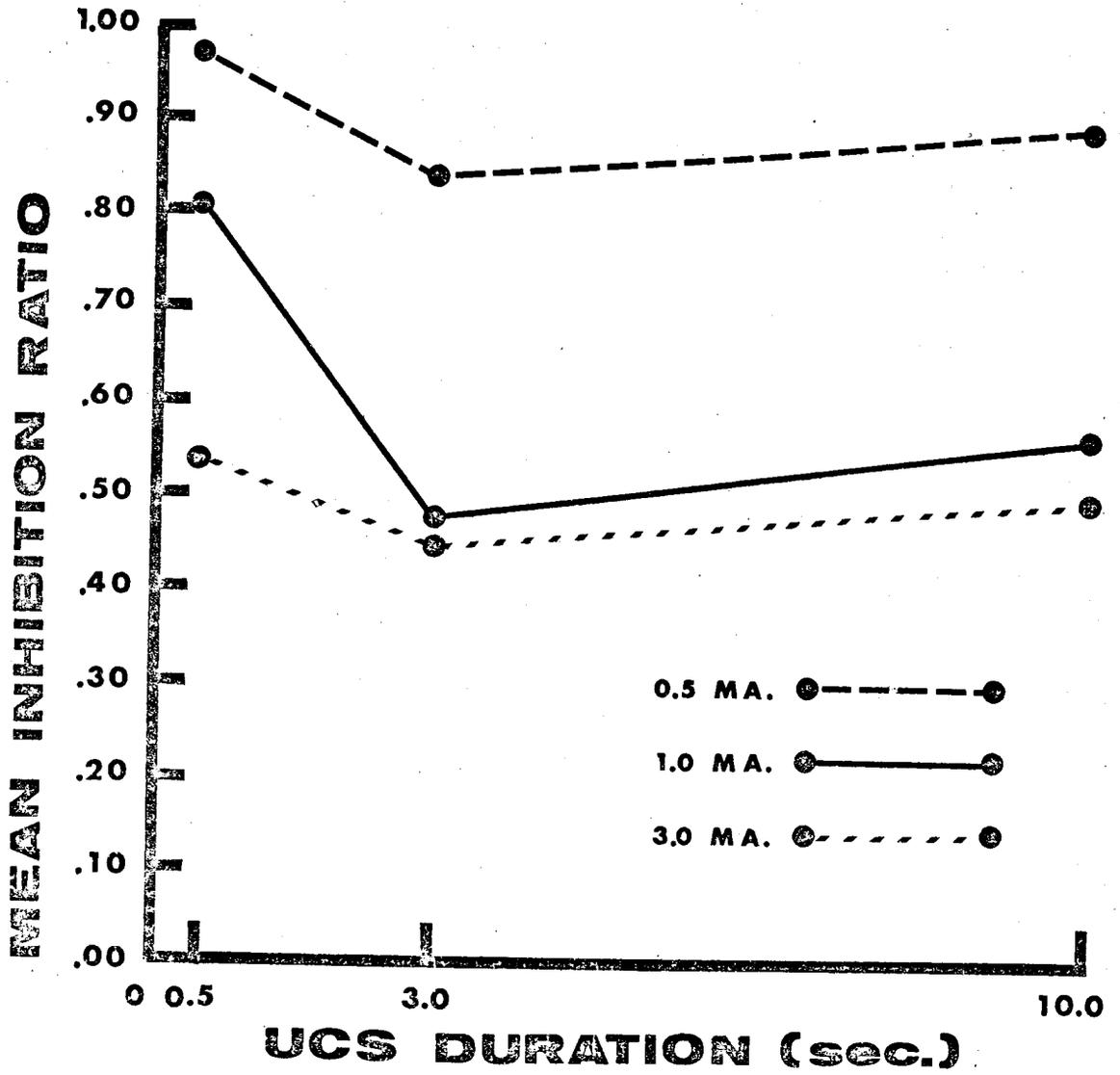

Fig. 6. Mean Inhibition Ratio as a Function of UCS Duration and UCS Intensity (collapsed across Days 12-16)

Table 3

Summary of Newman-Keuls Procedure Administered to Test Differences Between Means of UCS Duration Levels During Conditioned Punishment

	Means	3.0 sec. 5.90	10.0 sec. 6.59	0.5 sec. 7.73	Shortest Significant Ranges for $p < .05$
3.0 sec.	5.90	--	.69	1.83	$R_2 = .74$
10.0 sec.	6.59	--	--	1.14	$R_3 = .88$

3.0 sec. 10.0 sec. 0.5 sec.*

*Any two UCS durations not underscored by the same line differ at $p < .05$ level of Significance.

$S_{\bar{X}} = .26$, $df = 54$

effect of UCS Duration is plotted as a function of Days 12-16 in Figure 11 in Appendix C)

As expected, UCS Intensity was a significant variable (F=16.54, df=2/54, $p < .001$). The grand means of the three levels of UCS Intensity are plotted in Figure 7. The graph indicates that conditioned fear is an increasing monotonic function of UCS Intensity. The results of the Newman-Keuls procedure which was applied to the grand means of UCS Intensity are summarized in Table 4. All possible pairs of the three means differed significantly ($p < .01$).

The Within Ss factor Days was also significant (F= 124.13, df=4/216, $p < .001$). Figure 8 shows that bar-pressing behavior progressively recovered over the five days. This finding was predicted, since the CS was never followed by the UCS during conditioned punishment and the fear response gradually extinguished.

The only significant interaction was that of Days by UCS Intensity (F=5.81, df=8/216, $p < .01$). The main effect of UCS Intensity is plotted as a function of Days 12-16 in Figure 9. The relative effects of the three levels of UCS Intensity remained the same until Day 16 when the gradients of the 1.0-ma. and 3.0-ma. levels may be seen to have crossed. A separate analysis of variance was applied to the data for each day. The results of these five analyses are presented in Tables 5-9 for Days 12-16, respectively.

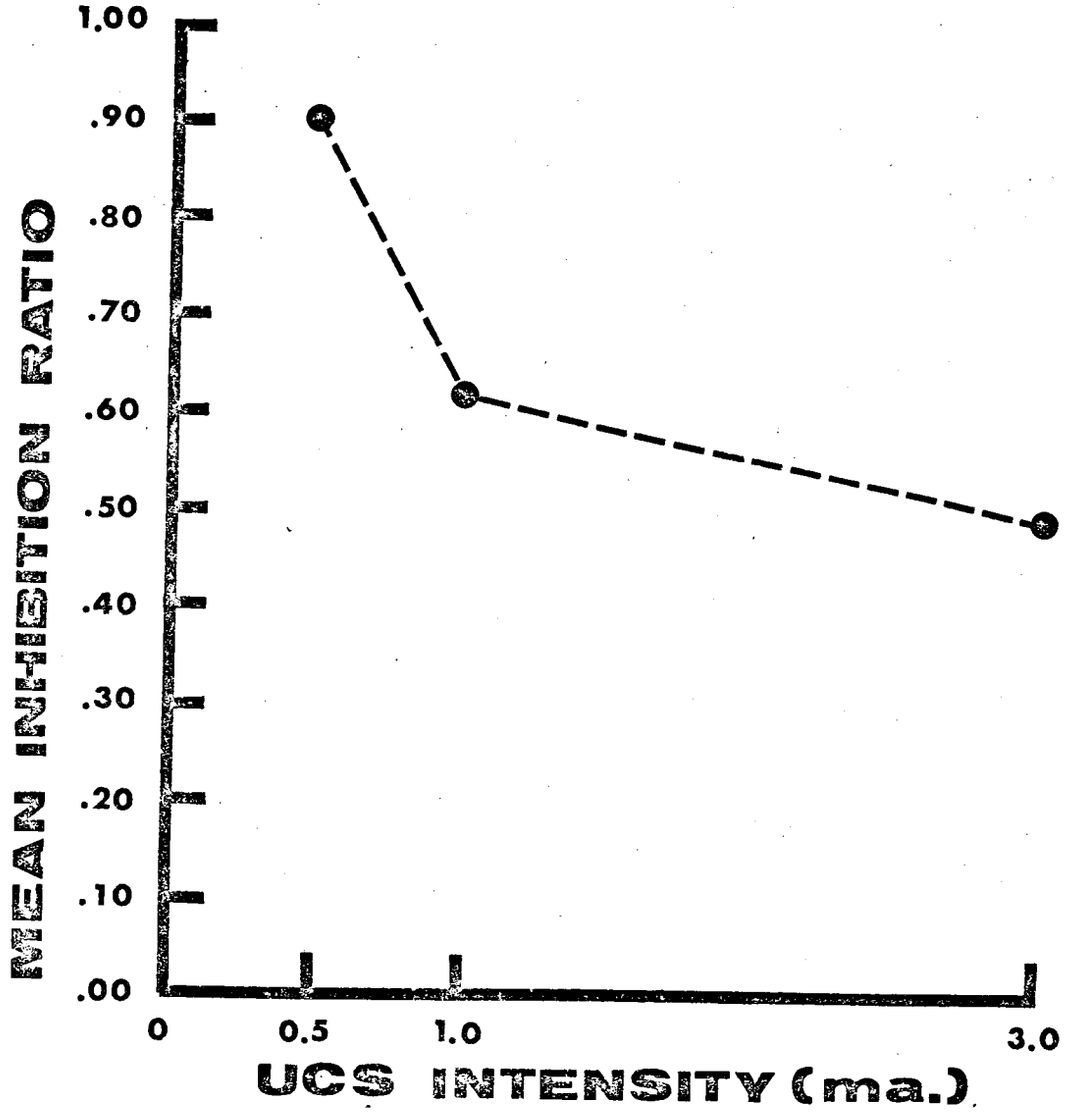

Fig. 7. Mean Inhibition Ratio as a Function of UCS Intensity (collapsed across UCS Duration and Days 12-16)

Table 4

Summary of Newman-Keuls Procedure Administered to Test Differences Between Means of UCS Intensity Levels During Conditioned Punishment

	Means	3.0 ma. 4.98	1.0 ma. 6.20	0.5 ma. 9.03	Shortest Significant Ranges for $p < .01$
3.0 ma.	4.98	--	1.22	4.05	$R_2 = .98$
1.0 ma.	6.20	--	--	2.83	$R_3 = 1.11$

3.0 ma. 1.0 ma. 0.5 ma.*

*Any two UCS intensities not underscored by the same line differ at $p < .01$ level of significance.

$S_{\bar{X}} = .26$, $df = 54$

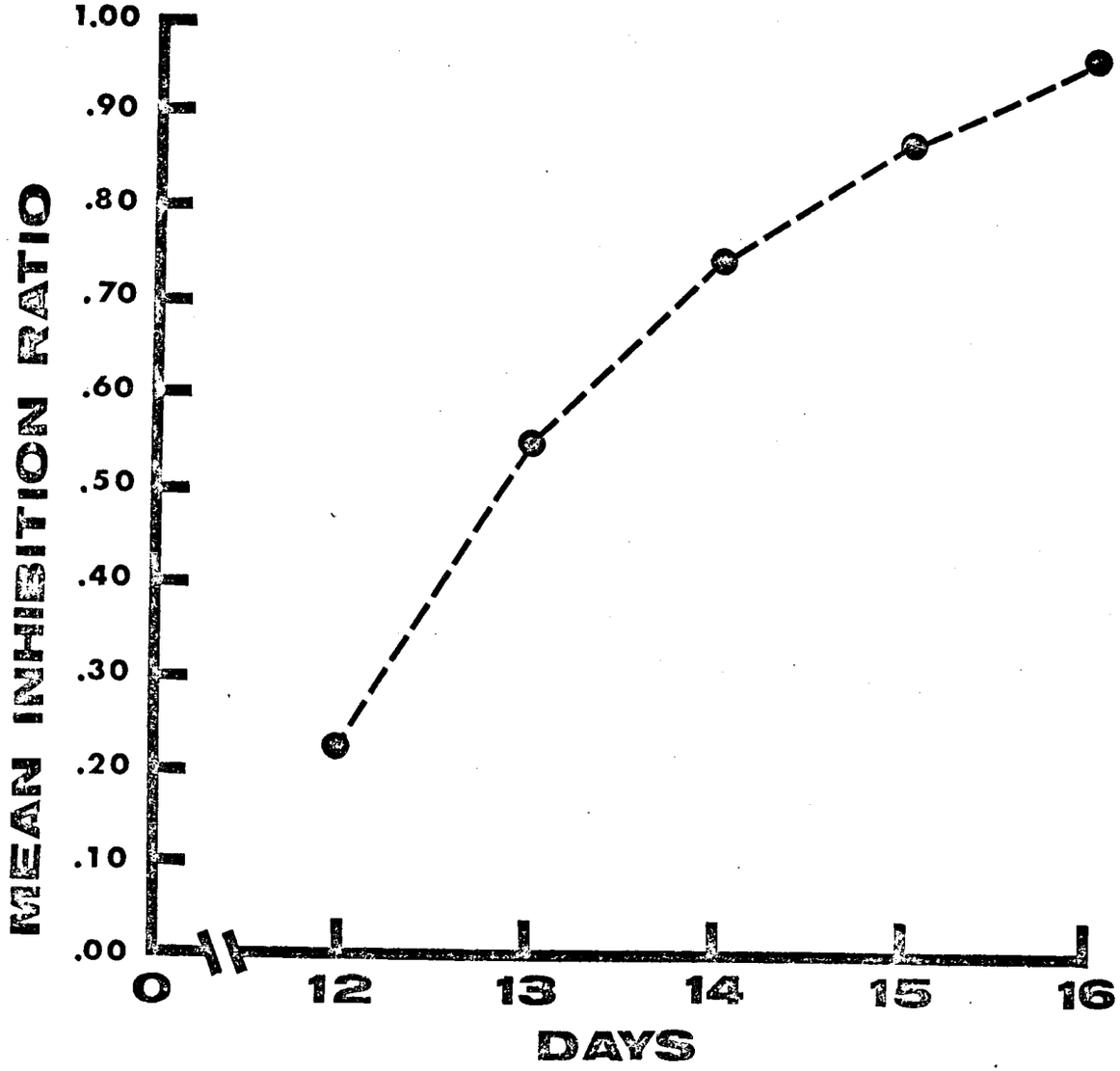

Fig. 8. Mean Inhibition Ratio as a Function of Days 12-16 (collapsed across UCS Duration and UCS Intensity)

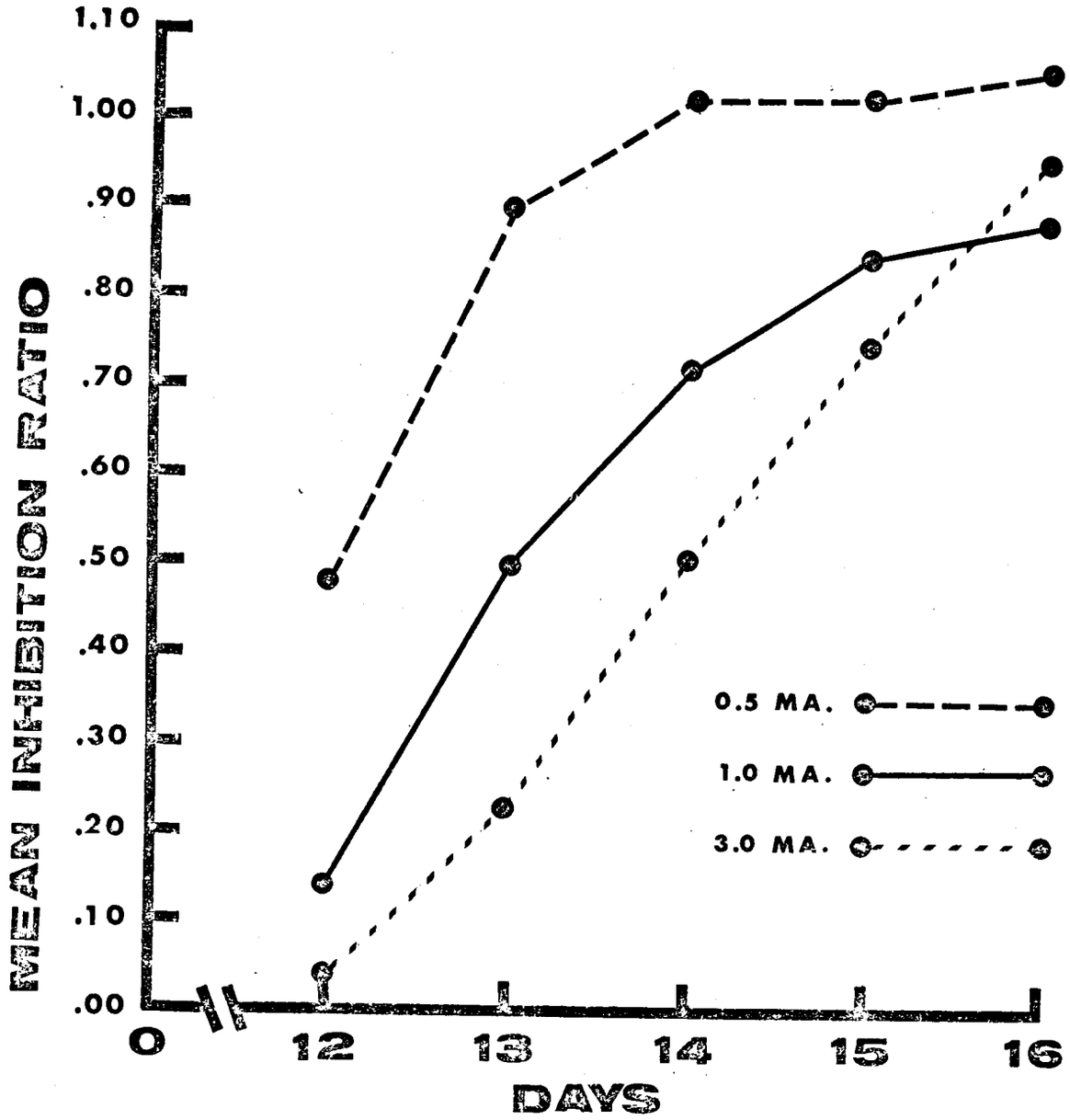

Fig. 9. Mean Inhibition Ratio as a Function of UCS Intensity and Days 12-16 (collapsed across UCS Duration)

Table 5

Summary of Analysis of Variance and Grand Means of Bar-press Inhibition Ratios for the Nine Experimental Groups on Day 12

Source	df	Mean	MS	F	p
Between Groups	(8)				
UCS Duration (DUR)	2		12.05	1.61	
0.5 sec.		2.76			
3.0 sec.		1.37			
10.0 sec.		2.59			
UCS Intensity (INT)	2		112.42	15.01	<.001
0.5 ma.		4.85			
1.0 ma.		1.41			
3.0 ma.		0.45			
DUR X INT	4		3.29	.44	
Within Groups	54		7.49		
Total	62				

Table 6

Summary of Analysis of Variance and Grand Means of Bar-press Inhibition Ratios for the Nine Experimental Groups on Day 13

Source	df	Mean	MS	F	p
Between Groups	(8)				
UCS Duration (DUR)	2		29.62	2.97	
0.5 sec.		6.63			
3.0 sec.		4.26			
10.0 sec.		5.47			
UCS Intensity (INT)	2		238.62	23.96	$< .001$
0.5 ma.		9.03			
1.0 ma.		5.00			
3.0 ma.		2.33			
DUR X INT	4		5.30	.53	
Within Groups	54		9.96		
Total	62				

Table 7

Summary of Analysis of Variance and Grand Means of Bar-press Inhibition Ratios for the Nine Experimental Groups on Day 14

Source	df	Mean	MS	F	p
Between Groups	(8)				
UCS Duration (DUR)	2		23.18	1.92	
0.5 sec.		8.70			
3.0 sec.		6.70			
10.0 sec.		7.16			
UCS Intensity (INT)	2		148.50	12.33	<.001
0.5 ma.		10.34			
1.0 ma.		7.16			
3.0 ma.		5.06			
DUR X INT	4		8.91	.74	
Within Groups	54		12.04		
Total	62				

Table 8

Summary of Analysis of Variance and Grand Means of Bar-press Inhibition Ratios for the Nine Experimental Groups on Day 15

Source	df	Mean	MS	F	p
Between Groups	(8)				
UCS Duration (DUR)	2		23.22	2.35	
0.5 sec.		9.97			
3.0 sec.		8.26			
10.0 sec.		8.05			
UCS Intensity (INT)	2		41.33	4.19	<.01
0.5 ma.		10.26			
1.0 ma.		8.53			
3.0 ma.		7.49			
DUR X INT	4		5.84	.59	
Within Groups	54		9.87		
Total	62				

Table 9

Summary of Analysis of Variance and Grand Means of Bar-press Inhibition Ratios for the Nine Experimental Groups on Day 16

Source	df	Mean	MS	F	p
Between Groups	(8)				
UCS Duration	2		14.64	2.42	
0.5 sec.		10.59			
3.0 sec.		8.92			
10.0 sec.		9.68			
UCS Intensity	2		16.71	2.76	
0.5 ma.		10.68			
1.0 ma.		8.91			
3.0 ma.		9.60			
DUR X INT	4		5.04	.83	
Within Groups	54		6.06		
Total	62				

The effect of UCS Intensity is shown to have been significant on Days 12-15 (F=15.01, 23.96, 12.33, and 4.19, df= 2/54 for each, $p < .001$, $< .001$, $< .001$, and $< .01$, respectively) but not on Day 16 (F=2.76, df=2/54). Thus, the interaction appears to have resulted from the data on Day 16. This is not surprisingly, because the fear of the CS had probably, for the most part, extinguished for all three groups by Day 16 when the groups were again bar-pressing at approximately equal rates.

The performances of the control group and its respective experimental group, i.e., the group which received the 3.0-sec. UCS at the 1.0-ma. level of intensity, are shown in Figure 10 for Days 12-16. The graph indicates that bar-press performance of the control group was to some extent inhibited by the presentation of the CS on Day 12, although on the remaining four days (Days 13-16), rates of bar-pressing for that group were close to normal. Bar-press performance for the experimental group never did return to normal. In order to determine whether the two groups statistically differed in performance, separate t-tests were performed for each of Days 12-16. The results of these five tests are presented in Table 10. Only on Days 12, 13, and 14 did the two groups differ significantly in performance (t=4.76, 4.34, and 2.52, df=12 for each, $p < .001$, $< .001$, $< .005$, for Days 12, 13, and 14, respectively).

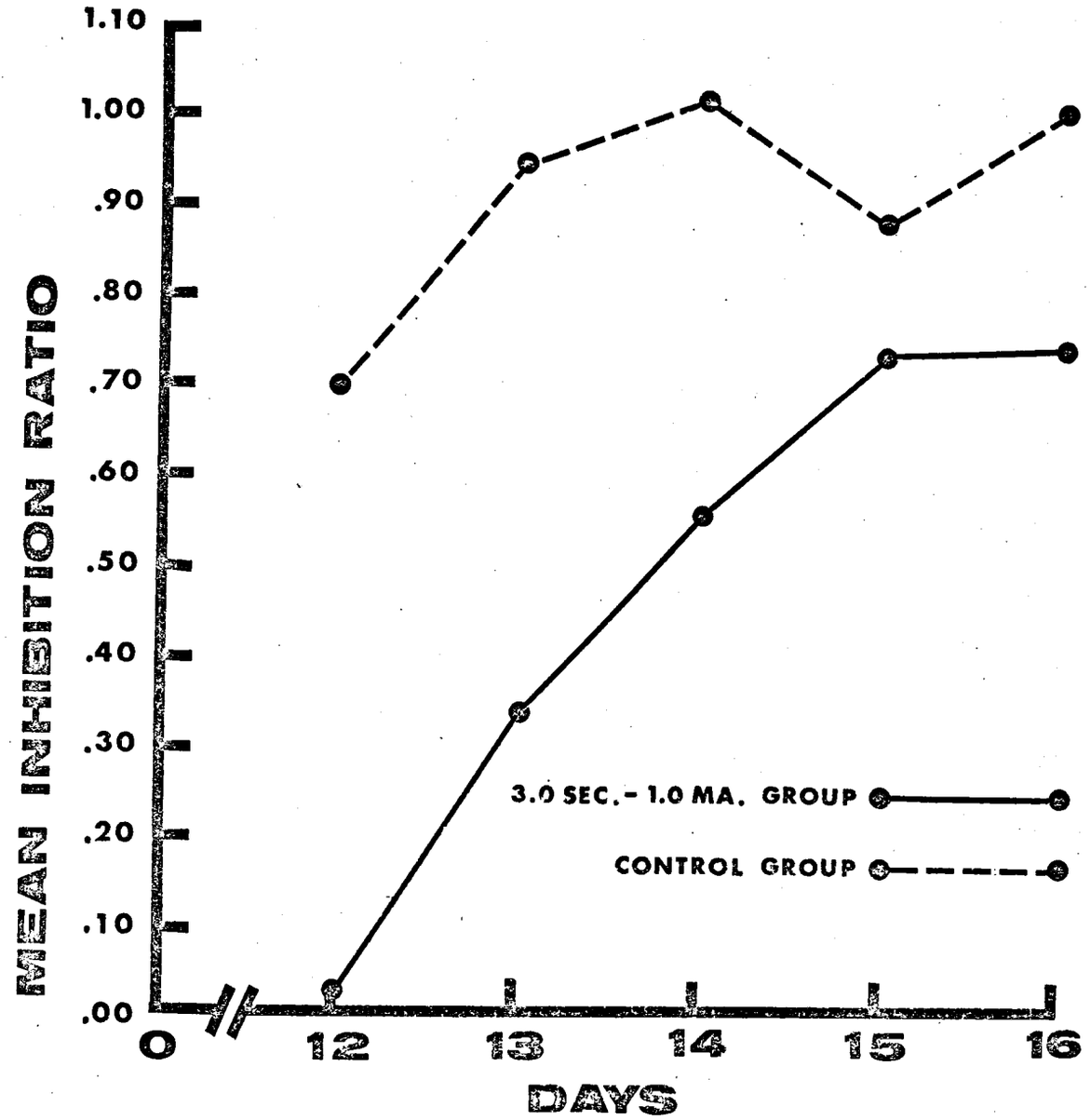

Fig. 10. Mean Inhibition Ratios of the Control Group and Its Respective Experimental Group as a Function of Days 12-16

Table 10

Summary of t-tests Comparing Means of 3.0-sec. -- 1.0-ma. Group with Control Group for Each of Days-12-16

Day	df	t	p
12	12	4.76	< .001
13	12	4.34	< .001
14	12	2.52	< .05
15	12	.73	
16	12	1.28	

The number of bar-press responses made by each S on each of Days 4-16 is presented in Appendix D. Also, the inhibition ratio for each S on each of Days 12-16 is presented in Appendix E.

Chapter 4

DISCUSSION

The results of the present along with those of Overmier (1966a, 1966b) are consistent with the intuitive notion that the magnitude of conditioned fear is an increasing function of UCS duration. Moreover, the shape of this function appears to be independent of the level of UCS intensity. Because the 3.0-sec. and 10.0-sec. levels of UCS duration both differed from the 0.5-sec. level but not from each other, it appears that the effect of UCS duration approaches a maximum limit at 3.0 sec. (at least when 25 CS-UCS pairings are administered). That is to say, increasing the duration of the UCS beyond the 3.0-sec. level will result in little, if any, increase in the amount of fear conditioned to the CS.

In direct contrast to the present findings are those of Bitterman, et al. (1952) which failed to find differences in the strength of GSRs when comparing the effects of 0.5-sec. and 3.0-sec. UCSs. According to Wegner and Zeaman (1958), the absence of differences in the Bitterman et al. study may have been a result of each S receiving conditioning with both UCS durations. Two light bulbs, one mounted above the other, were used to present the CSs. During conditioning, one CS was paired with a 0.5-sec. shock and the other CS

was paired with a 3.0-sec. shock. Wegner and Zeaman stated that although Ss may have been able to report that they learned which signal was paired with a particular duration of shock, stimulus generalization may still have occurred at the autonomic level.

The results of Wegner and Zeaman (1958), who found no differences in the magnitude of heart rate as a function of UCS duration (0.1, 2.0, 6.0, and 15.0 sec.), are also not in agreement with the present results. Overmier (1966b) also failed to find differences in conditioning as a function of UCS duration (0.5 sec. and 50.0 sec.) when using cardiac measures, but he did find differences in conditioning when he used an instrumental response measure (transfer of avoidance training). Therefore, the lack of differences in the Wegner and Zeaman research may have been, as suggested by Overmier, a result of cardiac indices not being sensitive enough to detect differences in amounts of fear.

Sawrey and Sawrey (1968) concluded that the effect of UCS duration is negligible in conditioning fear. Although not statistically significant, their results showed that Ss conditioned with a .75-sec. UCS incurred a higher frequency of stomach ulceration than Ss conditioned with a .25-sec. UCS. Since the difference in duration of the two UCSs was relatively small (i.e., only 0.5-sec.) , any differential amounts of fear conditioned by these UCSs were probably

slight and, consequently, difficult to detect.

Empirical confirmation was given to the conjecture by Mowrer and Solomon (1954) that a 0.5-sec. UCS would produce the least amount of fear of the three durations tested in the present study. The results of the present study did not indicate, as did the results of Mowrer and Solomon, that a 3.0-sec. UCS is less effective than a 10.0-sec. UCS. Thus, increasing the number of CS-UCS pairings from 5 (the number used by Mowrer and Solomon) to 25 did not result in magnifying the differences in the effects of the 3.0-sec. and 10.0-sec. UCSs as was predicted by the present E before the start of the experiment. In fact, increasing the number of CS-UCS pairings may possibly have eliminated any differences between the effects of the two durations which may have existed if a lesser number of CS-UCS pairings were presented.

The findings of Strouthes (1965) which indicated that Ss feared a CS previously paired with a 1.90-sec. UCS less than a CS previously paired with either a .25-sec. UCS or a .85-sec. UCS are also inconsistent with the present findings. It is questionable whether Strouthes' results really indicated differences in conditioned fear, because intergroup differences in running speed were found only on the first of 25 test trials. Since Strouthes did not employ a pseudoconditioning control group, it is not certain whether

the differences in performance on the first test trial were a result of the forward conditioning procedure. A possible criticism of Strouthes' procedure is that the duration of the CS when presented in the runway was determined by the running speed of S and was necessarily longer than the CS presented during conditioning which was .30-sec. in length. Consequently, S may have perceived the CS in the runway as being quantitatively different from the CS experienced during conditioning. Strouthes recognized that the finding of no inter-group differences in running speed on the remaining 24 trials may have been a result of the running response competing too successfully with the fear response elicited by the CS. At any rate, caution should be taken when making inferences concerning the role of UCS duration from the results of Strouthes' study.

The findings of the present study indicated that at each level of UCS intensity the 3.0-sec. UCS was the most effective in conditioning fear and was followed by the 10.0-sec. UCS and then by the 0.5-sec. UCS, although the difference between the 3.0-sec. and 10.0-sec. levels of UCS duration was not statistically significant. Interestingly, findings of a study by Church, LoLordo, Overmier, Solomon, and Turner (1966, Experiment I) indicated that a 3.0-sec. UCS may actually be subjectively more severe than either a 10.0-sec. UCS or a 0.5-sec. UCS. Each of their Ss, curarized

mongrel dogs, received twelve series of electric shocks differing as to duration (0.1, 0.5, 2.5, 5.0, and 10.0 sec.) and intensity (2.0, 4.0, 6.0, and 8.0 ma.). Two indices of shock severity were employed, namely, heart rate acceleration during shock stimulation and heart rate deceleration during post-shock recovery. As expected, shock severity was shown to be a positive monotonic function of shock intensity; however, both indices showed shock severity to be an inverted U-shaped function of shock duration. Severity was shown to increase up to durations of 2.5 sec. and 5.0 sec. and then to decrease at the duration of 10.0 sec. In response to these findings, Church et al. suggested that the intermediate-duration shocks were either "more severe" or that

> cardiac responses may indicate the severity of pain only during some recent, short interval of time, and some fairly rapid adaptation process results in the later intervals of a long shock being less severe than the earlier intervals (p.4).

If a 10.0-sec. electric shock is really less severe than a 3.0-sec. shock, then it may be questioned why the findings of Mowrer and Solomon (1954) indicated a tendency for the 10.0-sec. UCS to be more effective in conditioning than the 3.0-sec. UCS. Shock severity may be related to the number of UCS presentations administered to S. Each of the Ss in the Mowrer and Solomon study received a total of only 5 shocks, while each S in the Church et al. study received a

total of 240 shocks, i.e., 48 shocks at each level of duration. Perhaps when a small number of shocks, such as 5, are administered, a 10.0-sec. shock is perceived as being more severe than a 3.0-sec. shock. On the other hand, when a larger number of shocks are administered, S may in some way come to adapt to the longer shock and perceive it as being less severe than one of shorter duration. The findings of Church et al. along with those of the present experiment should encourage further research whose aim is to determine whether an inverted U-shaped function really does exist.

Bar-press performance for the control group appeared to be affected by the response-contingent presentation of the CS only on the first day (Day 12) of conditioned punishment. Since the CS had never previously been presented while S was bar-pressing, it is likely that the slight inhibition of bar-pressing on Day 12 was a result of pseudoconditioning or investigatory responding.[6] It is, therefore, quite possible that the inhibition of bar-pressing for the experimental groups on Day 12 was due to both conditioned and unconditioned effects of the CS. Since the control group bar-pressed at its normal rate after Day 12, it may be assumed

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[6]Investigatory behavior refers to behavior in which S is attending to a novel stimulus. In this case, the mere presentation of the CS may be considered novel, because the CS was never presented to S while S was in the operant chamber.

that the inter-group differences in the degree of bar-press inhibition on each of Days 13-16 can be attributed solely to the different amounts of conditioned fear elicited by the CS. It is also possible that some of the inhibition of bar-pressing for the control group on Day 12 was a result of the CS acquiring some ability to elicit fear through higher-order conditioning. During fear conditioning, the apparatus cues of the fear-conditioning compartment as well as other situational cues were present when the UCS was presented and, therefore, may have been conditioned to elicit fear. These newly conditioned stimuli (i.e., the apparatus and situational cues) may then have fulfilled the role of the UCS in conditioning fear to the discrete CS (i.e., the tone).

Early studies which varied UCS duration (Bitterman et al., 1952; Mowrer and Solomon, 1954) were not primarily interested in ascertaining the role of UCS duration per se but were designed to test two theoretical views, contiguity (Mowrer, 1951) vs. drive-reduction (Hull, 1943), concerning how the fear response is acquired. The contiguity position proposed that the necessary and sufficient condition for the learning of fear is merely the proper temporal contiguity between the CS and the unconditioned fear response. This condition is met when the forward conditioning procedure is used where the CS closely precedes the UCS and when the

onset of the UCS elicits the unconditioned fear response. According to the drive-reduction position, not only is it necessary for the CS and the unconditioned fear response to be temporally contiguous, but a reduction or termination of a drive must occur soon after the elicitation of the fear response; this latter condition is assumed to be met when the painful UCS terminates. The typical design employed by these early studies was to present a CS whose duration was the same for all experimental groups, followed by a UCS whose duration was different for each of the experimental groups. For each experimental group, the termination of the CS and the onset of the UCS coincided. Since the onset of the UCS elicited the unconditioned fear response, the temporal contiguity between the CS and the fear response would necessarily have been the same for all of the groups. Thus, the groups differed only with respect to the duration of the UCS and the temporal interval between the CS and the termination of the UCS. It was reasoned in these studies that the drive-reduction position would have to predict an inverse relationship between the magnitude of conditioned fear and UCS duration, because it was assumed that long UCSs allowed a greater delay in reinforcement than did short UCSs (in this case, the delay of reinforcement would be the interval between the onset of the CS and the termination of the UCS).

The design of the present experiment was virtually the same as the design just described. By employing the reasoning presented in these early studies, the results of the present study would have to be considered as evidence against the drive-reduction position. However, Miller (1951) suggested that the delay of reinforcement may not be the only factor which determines the efficacy of fear conditioning. For example, a long aversive UCS, through temporal summation, may be perceived by S as being more severe than a short aversive UCS. Since in Hull's early system (Hull, 1943) the growth in habit strength was, among other things, considered to be an increasing function of the amount of drive reduction, it may then be assumed that the strength of conditioned fear is also an increasing function of the amount of drive reduction. Hence, the findings of the present study may actually be amenable to a drive-reduction interpretation. Because both the 3.0-sec. and the 10.0-sec. UCSs resulted in more fear being conditioned to the CS than did the 0.5-sec. UCS, it may be conjectured that the greater amounts of drive reduction which resulted from the termination of the two longer UCSs were enough to overcome the disadvantage of having longer delays in reinforcement.

The contiguity position was described by Mowrer and Solomon (1954) as considering fear conditioning to be "dependent upon what happens at shock onset" (p.16). That is,

according to Mowrer and Solomon, the same fear response becomes conditioned to the CS regardless of the duration of the UCS. If this is indeed the case, the only results which could support the contiguity position are those which show that conditioned fear is unrelated to UCS duration. Consequently, the results of the present study and those of Overmier (1966a, 1966b) do not support the contiguity position.

Chapter 5

SUMMARY

The intuitive notion that a protracted UCS should result in the conditioning of a greater amount of fear than a brief UCS has not received consistent support in the experimental literature. The purpose of the present study was to ascertain further the role of UCS duration in the conditioning of fear. The effects of three values of UCS duration were compared, namely, 0.5, 3.0, and 10.0 sec. Moreover, each UCS duration was investigated at three levels of UCS intensity, namely, 0.5, 1.0, and 3.0 ma. A between-subjects 3 by 3 factorial design was used. Thus, there were nine experimental groups. In addition, a pseudoconditioning control group was employed.

A conditioned punishment procedure was used to index the amount of conditioned fear. The Ss, male albino rats, were first trained in an operant conditioning chamber to bar-press for food pellets. In a different apparatus, the same Ss were given fear conditioning when a discrete CS (2.0-sec. tone) was presented prior to the onset of the UCS. Over a five-day period, a total of 25 CS-UCS pairings were administered to each S. The amount of fear conditioned to the CS was assessed during five subsequent 15.0-min. conditioned punishment sessions in the operant chamber when the

presentation of the CS, alone, was made contingent upon the emitting of a bar-press response by S. It was assumed that the amount of fear conditioned to the CS was a positive function of the extent of bar-press inhibition.

The results showed that the 0.5-sec. UCS was significantly less effective in conditioning fear than both the 3.0-sec. and 10.0-sec. UCSs. The 3.0-sec. UCS and the 10.0-sec. UCS did not differ significantly in their abilities to condition fear. The effects of the three UCS durations were independent of the level of UCS intensity. In agreement with the findings of previous studies, the magnitude of conditioned fear was shown to be an increasing function of UCS intensity. By the fifth conditioned punishment session, fear of the CS had, for the most part, extinguished for all of the groups. These results are amenable to a drive-reduction interpretation of how fear is acquired. They do not support a strict contiguity position as described by Mowrer (1951).

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APPENDIXES

APPENDIX A

Table 11

Summary of the Findings of Studies Which Manipulated UCS Duration as a Parameter of Conditioned Fear

Study	UCS Durations Employed	Fear Index	Effects of UCS Durations on Fear Conditioning
Bitterman et al. (1952)	0.5 sec. and 3.0 sec.	Conditioned GSR	0.5 sec. = 3.0 sec.
Mowrer and Solomon (1954)	3.0, 4.0, 7.0, and 10.0 sec.	Conditioned Punishment	(4.0 sec. = 7.0 sec. = 10.0 sec.) 3.0 sec. (10% level of confidence)
Overmier (1966a)	0.5 sec. and 50.0 sec.	Transfer of Avoidance Training	50.0 sec. 0.5 sec.
Overmier (1966b)	0.5 sec. and 50.0 sec.	Transfer of Avoidance Training & Cardiac Measures	50.0 sec. 0.5 sec. 0.5 sec. = 50.0 sec.
Sawrey and Sawrey (1968)	.25 sec. and .75 sec.	Stomach Ulceration	.25 sec. = .75 sec.
Strouthes (1965)	.25, .85, and 1.90 sec.	Running Speed	(.25 sec. = .85 sec.) 1.90 sec.
Wegner and Zeaman (1958)	0.1, 2.0, 6.0, and 15.0 sec.	Cardiac Measure	0.1 sec. = 2.0 sec. = 6.0 sec. = 15.0 sec.

APPENDIX B

Table 12

Orders of Presentation of the CSs and UCSs for the Control Group On Days 12-16

Day 12		Day 13		Day 14		Day 15		Day 16	
Stimulus	Time	Stimulus	Time	Stimulus	Time	Stimulus	Time	Stimulus	Time
UCS	4'09"	UCS	1'17"	UCS	1'08"	CS	3'18"	UCS	3'07"
UCS	4'23"	CS	1'40"	UCS	3'25"	CS	4'18"	UCS	5'49"
UCS	6'03"	UCS	3'18"	CS	3'43"	UCS	4'31"	CS	6'12"
CS	6'41"	CS	3'36"	CS	4'26"	UCS	5'02"	CS	6'30"
CS	8'06"	CS	4'50"	CS	8'19"	UCS	5'59"	UCS	6'48"
CS	8'19"	UCS	7'24"	CS	8'35"	UCS	6'20"	UCS	8'34"
CS	9'43"	CS	9'42"	UCS	10'40"	UCS	8'57"	CS	9'55"
CS	10'06"	UCS	10'06"	UCS	11'51"	CS	10'57"	UCS	10'57"
UCS	10'31"	UCS	12'13"	CS	11'57"	CS	12'49"	CS	11'01"
UCS	12'12"	CS	12'26"	UCS	14'03"	CS	13'26"	CS	12'26"

APPENDIX C

MEAN INHIBITION RATIO AS A FUNCTION OF UCS DURATION AND DAYS 12-16

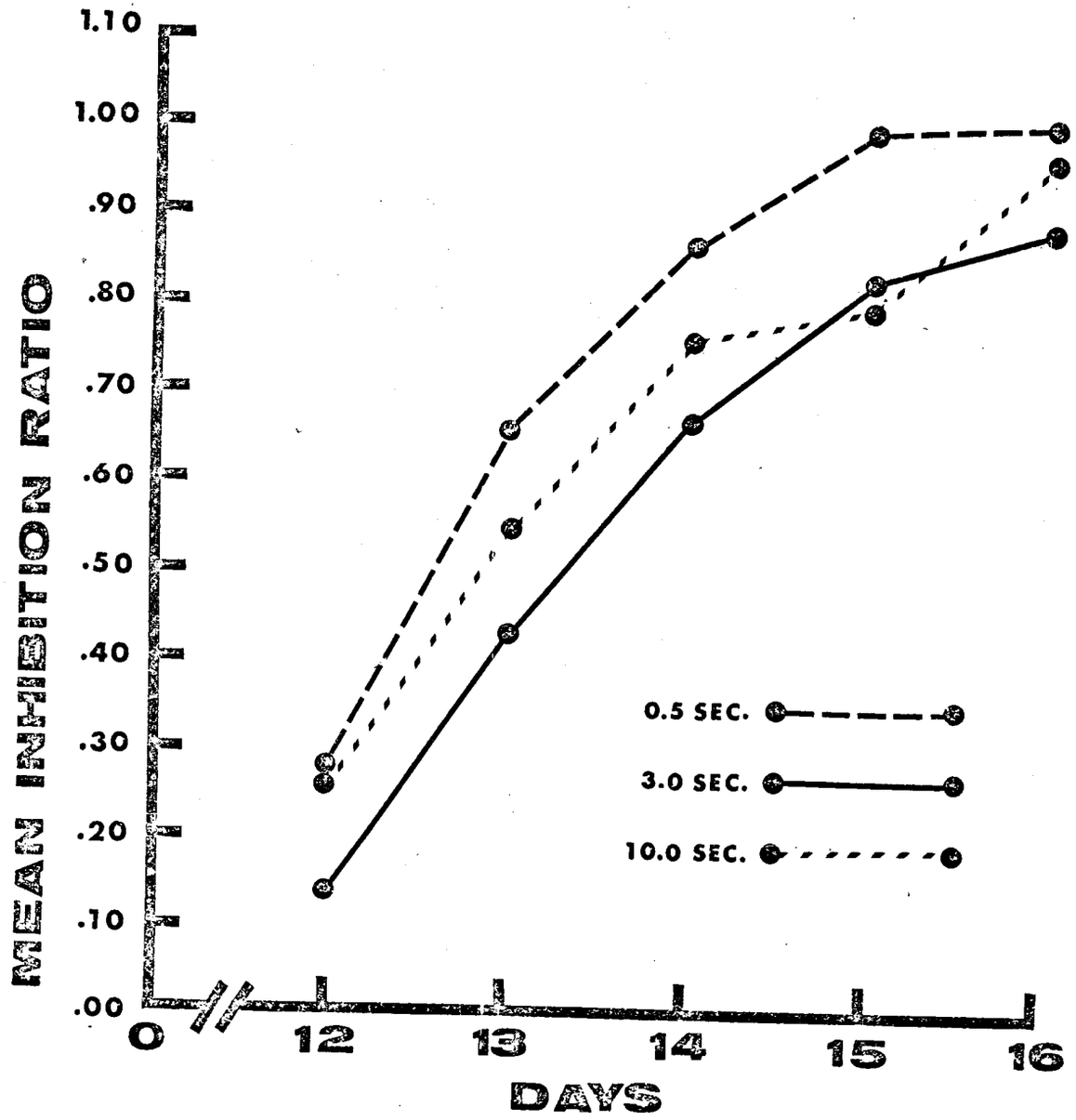

Fig. 11. Mean Inhibition Ratio as a Function of UCS Duration and Days 12-16 (collapsed across UCS Intensity)

APPENDIX D

Number of Daily Bar-presses (Days 4-16)

Group: 0.5-sec. -- 0.5-ma.

Subject	Day												
	4	5	6	7	8	9	10	11	12	13	14	15	16
1	107	81	99	103	107	117	126	130	51	118	127	123	142
8	118	139	149	176	186	154	183	186	176	190	220	196	186
11	187	88	182	166	186	178	167	187	185	203	198	191	189
16	113	141	138	129	136	104	77	72	64	93	92	88	111
50	129	98	125	141	137	142	145	158	82	120	117	153	157
55	115	84	145	146	148	150	132	169	28	159	165	165	166
72	150	129	143	142	167	172	148	174	24	165	164	172	174

Group: 3.0-sec. -- 0.5-ma.

Subject	Day												
	4	5	6	7	8	9	10	11	12	13	14	15	16
9	89	98	114	119	113	112	116	113	10	28	120	128	138
12	117	140	144	145	162	172	159	165	159	188	112	181	174
20	137	157	150	135	142	126	121	108	12	85	134	144	126
23	150	132	134	141	166	138	152	149	142	153	171	130	162
41	83	104	119	132	160	161	158	188	16	116	167	172	176
52	128	123	133	128	175	184	162	182	8	94	179	171	180
68	90	102	120	118	140	145	145	141	14	122	144	138	140

APPENDIX D (continued)

Group: 10.0-sec. -- 0.5-ma.

Subject	Day												
	4	5	6	7	8	9	10	11	12	13	14	15	16
13	128	126	126	114	123	123	160	150	129	132	136	128	150
26	99	137	116	107	132	130	131	137	124	121	131	125	126
33	102	85	118	125	109	113	134	150	60	134	152	141	159
36	126	133	122	139	147	139	138	151	151	169	185	170	158
48	155	162	186	143	192	197	207	216	21	185	209	204	206
53	121	77	124	146	139	130	141	160	21	120	141	148	140
62	127	88	117	192	164	164	175	161	20	135	156	149	139

Group: 0.5-sec. -- 1.0-ma.

Subject	Day												
	4	5	6	7	8	9	10	11	12	13	14	15	16
2	107	149	160	180	174	174	188	172	11	127	169	182	183
3	103	113	111	126	134	143	142	143	42	131	161	174	156
19	96	83	129	128	109	124	125	120	7	5	69	125	125
31	160	137	143	160	166	147	115	131	13	9	142	162	152
43	107	133	166	165	189	199	192	204	11	100	184	178	176
51	124	96	116	124	117	134	131	131	99	126	160	150	155
69	135	117	136	161	158	163	170	172	23	135	168	183	180

Group: 3.0-sec. -- 1.0-ma.

Subject	Day												
	4	5	6	7	8	9	10	11	12	13	14	15	16
5	75	112	131	117	122	128	139	110	4	2	1	2	5
37	132	133	125	103	121	127	161	137	4	2	1	1	1
38	170	152	132	181	168	182	190	174	5	82	183	188	185
40	131	151	151	140	156	162	169	162	4	8	3	166	162
54	139	98	110	138	151	178	189	203	6	54	160	199	200
58	145	150	145	134	157	150	151	158	7	113	138	153	155
65	144	153	167	176	185	193	194	199	8	154	167	187	200

Group: 10.0-sec. -- 1.0-ma.

Subject	Day												
	4	5	6	7	8	9	10	11	12	13	14	15	16
10	96	110	99	81	109	119	107	116	3	3	1	0	2
21	137	140	100	137	171	157	160	170	151	163	176	182	165
28	121	143	161	169	179	169	165	170	6	6	84	166	162
39	66	107	171	113	149	152	161	155	4	6	2	37	134
63	119	120	142	153	164	173	168	197	37	178	148	127	184
67	120	78	141	141	149	164	174	162	8	107	146	155	170
73	105	96	121	122	137	148	158	154	5	57	136	168	165

APPENDIX D (continued)

Group: 0.5-sec. -- 3.0-ma.

Subject	Day												
	4	5	6	7	8	9	10	11	12	13	14	15	16
7	123	149	153	144	160	157	153	157	3	5	2	4	103
22	146	192	160	155	132	118	136	142	10	100	151	163	175
24	138	136	154	154	167	162	171	165	6	6	115	181	184
27	154	149	160	176	150	165	176	181	5	5	3	157	158
56	122	117	114	153	163	157	162	156	4	5	100	146	149
61	127	108	106	159	161	167	159	170	8	53	108	129	149
66	93	88	100	107	114	128	141	130	4	82	118	127	149

Group: 3.0-sec. -- 3.0-ma.

Subject	Day												
	4	5	6	7	8	9	10	11	12	13	14	15	16
4	115	126	122	116	118	122	117	124	6	2	28	93	132
15	115	77	125	92	121	116	125	120	6	3	72	115	108
17	115	151	163	147	166	178	176	179	7	36	83	88	93
18	136	137	152	170	173	177	171	173	4	2	1	74	131
46	167	166	178	189	194	191	180	171	8	25	151	172	191
57	137	99	118	154	152	171	145	162	2	2	4	55	127
59	107	148	112	162	142	155	154	114	12	148	150	152	146

APPENDIX D (continued)

Group: 10.0-sec. -- 3.0-ma.

Subject	Day												
	4	5	6	7	8	9	10	11	12	13	14	15	16
29	167	187	192	120	151	153	141	141	32	136	159	156	177
30	142	146	139	163	80	101	126	127	1	3	5	44	135
34	88	70	77	86	106	113	94	104	5	3	12	43	96
35	128	145	122	54	143	128	120	135	4	5	6	7	104
45	109	128	151	174	185	170	165	149	4	60	155	179	174
49	157	127	168	168	204	202	187	211	6	49	177	199	203
64	122	80	214	149	152	118	136	138	3	2	29	105	126

Group: Control

Subject													
	4	5	6	7	8	9	10	11	12	13	14	15	16
6	138	93	128	121	157	140	130	76	76	79	84	51	97
14	123	115	110	129	162	155	156	158	36	154	163	136	182
25	143	140	169	151	175	167	164	163	166	157	180	170	184
32	110	148	131	124	156	163	155	131	30	134	139	120	132
42	99	130	153	154	173	171	160	176	139	187	193	171	175
47	122	112	118	137	142	145	118	133	128	135	142	146	157
71	85	102	117	144	143	164	124	147	160	147	152	156	154

APPENDIX E

Daily Inhibition Ratios (Days 12-16)

Group: 0.5-sec. -- 0.5-ma.

Subject	Day				
	12	13	14	15	16
1	.40	.94	1.01	.98	1.13
8	.96	1.04	1.20	1.07	1.02
11	1.04	1.14	1.11	1.07	1.06
16	.83	1.21	1.20	1.14	1.44
50	.57	.83	.81	1.06	1.08
55	.19	1.06	1.10	1.10	1.11
72	.14	.96	.95	1.00	1.01

Group: 3.0-sec. -- 0.5-ma.

Subject	Day				
	12	13	14	15	16
9	.09	.25	1.06	1.13	1.22
12	.96	1.14	.68	1.10	1.06
20	.10	.70	1.11	1.19	1.04
23	.95	1.03	1.15	.87	1.09
41	.10	.72	1.04	1.07	1.09
52	.04	.52	.98	.94	.99
68	.10	.84	.99	.95	.96

Group: 10.0-sec. -- 0.5-ma.

Subject	Day				
	12	13	14	15	16
13	.86	.88	.91	.85	1.00
26	.95	.92	1.00	.95	.96
33	.45	1.00	1.13	1.05	1.19
36	1.09	1.22	1.33	1.22	1.14
48	.10	.89	1.01	.98	1.10
53	.15	.85	1.00	.91	.99
62	.12	.83	.95	.91	.85

APPENDIX E (continued)

Group: 0.5-sec. -- 1.0-ma.

Subject	Day				
	12	13	14	15	16
2	.06	.73	.97	1.05	1.05
3	.29	.92	1.13	1.22	1.09
19	.06	.04	.56	1.01	1.01
31	.10	1.00	1.08	1.24	1.16
43	.06	.50	.92	.89	.88
51	.70	.96	1.22	1.14	1.18
69	.14	.79	.99	1.08	1.06

Group: 3.0-sec. -- 1.0-ma.

Subject	Day				
	12	13	14	15	16
5	.03	.02	.01	.02	.04
37	.03	.02	.01	.01	.01
38	.03	.47	1.05	1.08	1.06
40	.02	.05	.22	1.02	1.00
54	.03	.29	.85	1.05	1.06
58	.05	.75	.91	1.01	1.03
65	.04	.79	.86	.96	1.03

Group: 10.0-sec. -- 1.0-ma.

Subject	Day				
	12	13	14	15	16
10	.03	.03	.01	.00	.02
21	.94	1.02	1.10	1.14	1.03
28	.04	.04	.50	.98	.96
39	.03	.04	.01	.24	.86
63	.21	1.03	.86	.73	1.06
67	.05	.65	.89	.94	1.04
73	.03	.37	.88	1.09	1.07

APPENDIX E (continued)

Group: 0.5-sec. -- 3.0-ma.

Subject	Day				
	12	13	14	15	16
7	.02	.03	.01	.02	.66
22	.07	.74	1.11	1.20	1.29
24	.04	.04	.70	1.10	1.12
27	.03	.03	.02	.89	.90
56	.02	.03	.64	.93	.95
61	.05	.32	.65	.77	.89
66	.03	.63	.91	.98	1.15

Group: 3.0-sec. -- 3.0-ma.

Subject	Day				
	12	13	14	15	16
4	.05	.02	.23	.76	1.08
15	.05	.02	.60	.98	.90
17	.04	.20	.47	.49	.52
18	.02	.01	.01	.43	.76
46	.04	.14	.84	.96	1.06
57	.01	.01	.02	.34	.78
59	.08	.96	.97	.99	.95

Group: 10.0-sec. -- 3.0-ma.

Subject	Day				
	12	13	14	15	16
29	.23	.96	1.13	1.11	1.26
30	.01	.02	.04	.35	1.07
34	.05	.03	.12	.41	.92
35	.03	.04	.05	.13	.81
45	.03	.40	1.04	1.20	1.17
49	.03	.24	.88	.98	1.00
64	.02	.02	.21	.70	.93

APPENDIX E (continued)

Group: Control					
Subject					
	12	13	14	15	16
6	.58	.61	.65	.39	.75
14	.23	.99	1.04	.87	1.17
25	1.01	.96	1.10	1.04	1.12
32	.19	.86	.90	.77	.85
42	.81	1.09	1.13	1.00	1.02
47	.96	1.02	1.07	1.10	1.18
71	1.09	1.00	1.03	1.06	1.05

BIOGRAPHICAL DATA

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Elementary School: Robert Louis Stevenson
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